

NOBLE GAS INVENTORY OF MICROMETEORITES COLLECTED AT THE TRANSANTARCTIC MOUNTAINS (TAM) AND INDICATIONS FOR THEIR PROVENANCE.

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Introduction: A variety of processes have been considered possibly contributing the volatiles including noble gases to the atmospheres of the terrestrial planets (e.g., [1-3]). Special consideration has been given to the concept of accretion of volatile-rich materials by the forming planets. This might include infalling planetesimals and dust, and could include material from the outer asteroid belt, as well as cometary material from the outer solar system. Currently, the dominant source of extraterrestrial material accreted by the Earth is represented by micrometeorites (MMs) with sizes mostly in the 100-300 μm range [3, 4]). Their role has been assessed by [3], who conclude that accretion of early micrometeorites played a major role in the formation of the terrestrial atmosphere and oceans. We have therefore set out to investigate in more detail the inventory of noble gases in MMs. Here we summarize some of our results obtained on MMs collected in micrometeorite traps of the Transantarctic Mountains [5].

Trapped noble gases: Concentrations in “unmelted” MMs are compared to those in CM meteorites (exemplified by CM2 Maribo) in Figure 1. While He has been largely lost, the abundance of Ne often exceeds that in CMs, because of higher abundances of trapped solar wind Ne. Ar, Kr, Xe are somewhat lower and quite variable. This is in line with our mineralogical observations on separate pieces of the analyzed MMs that mostly show similarities to ordinary chondrites of various types rather than CMs – contrary to the situation for recently fallen MMs recovered from ice and snow [6, 7]. Note, though, that uncertainty is induced by a) the fact that the MMs are often not homogeneous in composition (see the example of 45c29 below) and b) the complex interaction during passage through the terrestrial atmosphere. Among others, we found in several cases (two scoriaceous, one unmelted) Kr and Xe showing the signature of isotopically fractionated air [8].

Cosmic ray exposure: Neon is generally dominated by fractionated solar wind, but cosmogenic contributions are apparent in a number of cases. The abundance can be used to infer cosmic ray exposure and (due to the Poynting-Robertson effect) the distance from the sun where they began their travel [10]. In addition the isotopic composition of cosmogenic Ne contains information about irradiation conditions. From a comparison with model predictions [10] it follows that data for the MMs with the clearest cosmogenic signature are incompatible with irradiation by galactic cosmic rays (GCR) as small particles, but could have been exposed to GCR as part of a larger body or as small particles to solar cosmic rays (SCR). In the latter case a spectrum is required that is softer than the one favored in [10].

45c29: This MM is characterized by several unique features: a) high abundances not only of cosmogenic Ne but also cosmogenic argon, with extremely low cosmogenic $^{21}\text{Ne}/^{38}\text{Ar}$ in one analyzed piece, but less so in a second specimen, attesting to an inhomogeneous composition; b) evidence for radiogenic ^{129}Xe and fission Xe from ^{244}Pu . These properties are similar to, but not identical in all details, to achondrites or Ca-Al-rich inclusions (CAIs). Since for MMs derived from beyond ~ 4 a.u. the GCR contribution should exceed that from SCR [10], the high abundance of cosmogenic Ne is difficult to reconcile with its isotopic composition.

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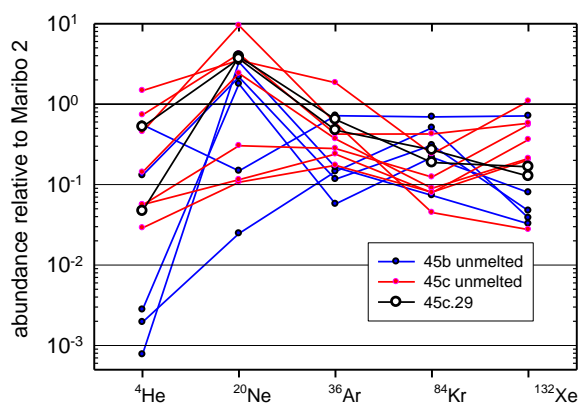


Fig. 1. Trapped noble gas abundances in nominally unmelted TAM MMs, normalized to CM Maribo [9]. One aliquot of the MMs shown as one additional “unmelted” MM had abundances below detection limit for at least one noble gas.